

1

BENDABLE DISPLAY APPARATUS AND METHOD OF MANUFACTURING THE SAME

CROSS REFERENCE TO RELATED APPLICATIONS

This application is a divisional of U.S. application Ser. No. 10/807,186 filed on Mar. 24, 2004 now U.S. Pat. No. 7,148,944, which is a continuation of PCT/JP03/06071 filed May 15, 2003, all of which claim priority to Japanese Patent Application No. 2003-134349 filed May 13, 2003, Japanese Patent Application No. 2002-143814 filed May 17, 2002, Japanese Patent Application No. 2002-143813 filed May 17, 2002, Japanese Patent Application No. 2002-143812 filed May 17, 2002. Each of these cross-referenced applications are incorporated by reference herein.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a display apparatus and a manufacturing method thereof, and, more particularly, to a structure of a display apparatus that can achieve reduction in thickness.

2. Description of the Related Art

Flat panel display apparatuses represented by a liquid crystal display apparatus are applied to various fields, taking advantage of such features as light weight, thin shape and low power consumption. In particular, a liquid crystal display apparatus is widely applied to mobile information apparatuses represented by personal computers.

In recent years, there is a demand for further reduction in thickness of the liquid crystal display apparatus. To meet the demand, there is an idea that a thin glass substrate is used. However, fabrication with use of a glass substrate that has a thickness of less than 0.5 mm may lead to a decrease in manufacturing yield, since conveyance, etc. thereof is difficult because of a problem of bending due to its own weight. A display apparatus formed with such a substrate may easily suffer crack or chip at its end part due to weak shock, and moreover the entirety of the apparatus may be broken. There is an alternative idea that a resin film, for instance, is used in place of the glass substrate. This, however, is not practical since constraints such as film formation temperatures are imposed.

On the other hand, a manufacturing method has been proposed, wherein the outer surface of one of substrates that are components of the liquid crystal apparatus is thinned by etching (see, e.g. Japanese Patent No. 2678325). According to this manufacturing method, one of the substrates is thinned to about 0.1 to 0.2 mm by etching, while the other substrate is about 0.3 to 1.1 mm thick and has a high strength as the substrate. Moreover, a sufficient strength of the liquid crystal display apparatus is achieved.

The liquid crystal display apparatus fabricated by this manufacturing method, however, still fails to realize the reduction in thickness and weight that is required in the market. With this manufacturing method, it is not possible to manufacture a liquid crystal display apparatus that is flexible while maintaining display performance.

BRIEF SUMMARY OF THE INVENTION

The present invention has been made in order to solve the above problems, and its object is to provide a display apparatus and a manufacturing method thereof, which can achieve further reduction in thickness while maintaining

2

display performance. In addition, the object of the invention is to provide a display apparatus and a manufacturing method thereof, which can achieve further reduction in thickness while having high durability.

In order to solve the problem and achieve the object, a first aspect of the invention provides a display apparatus having an optical material between a pair of substrates, and having a plurality of display pixel sections,

wherein each of the substrates has a glass substrate and a film that is attached to an outer surface of the glass substrate and has a thickness greater than a thickness of the glass substrate,

at least one of the films is formed of a polarizer plate, and each of the glass substrate is formed to have a thickness that permits bending of the display apparatus.

A second aspect of the invention provides a display apparatus having a plurality of display pixel sections on one of major surfaces of a substrate,

wherein the substrate has a glass substrate and a polarizer plate that is disposed to extend to an end part of the glass substrate on the other major surface of the substrate, and has a thickness greater than a thickness of the glass substrate, and

the glass substrate is formed to have a thickness that permits bending of the display apparatus.

A third aspect of the invention provides a method of manufacturing a display apparatus having an optical material between a pair of glass substrates comprising:

(a) a step of attaching the pair of glass substrates together with a predetermined distance;

(b) polishing an outer surface of each of the glass substrates to a thickness of 0.15 mm or less;

(c) attaching a film to the outer surface of at least one of the glass substrates, the film having a thickness greater than a thickness of the glass substrate; and

(d) cutting the film and the pair of glass substrates into a predetermined size.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING

FIG. 1 schematically shows the structure of a liquid crystal display apparatus according to an embodiment of the present invention;

FIG. 2 is a cross-sectional view schematically showing an example of the structure of a light-transmission type liquid crystal panel that is applicable to a liquid crystal display apparatus according to a first embodiment of the invention;

FIG. 3 is a cross-sectional view schematically showing an example of the structure of a light-reflection type liquid crystal panel that is applicable to a liquid crystal display apparatus according to a second embodiment of the invention;

FIG. 4 is a view for explaining a manufacturing method of a liquid crystal display panel according to an embodiment of the invention;

FIG. 5 is a view for explaining a manufacturing method of a liquid crystal display panel according to an embodiment of the invention;

FIG. 6A to FIG. 6C are views illustrating the manufacturing method of the liquid crystal display panel according to the embodiment of the invention;

FIG. 7A to FIG. 7C are views illustrating the manufacturing method of the liquid crystal display panel according to the embodiment of the invention;